Does competition from introduced grasses affect *Festuca novae-zelandiae* tussock growth and survival?

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Abstract

Over the last century short-tussock grassland has undergone a process of radical change from a community dominated by indigenous grasses, forbs and shrubs to one dominated by adventive species. However, whether this change is due to changing disturbance regimes or to a direct competitive effect of adventive species on indigenous species, has not been investigated experimentally. The aim of this study was to experimentally examine the competitive effect of adventive grass species on *Festuca novae-zelandiae*. Adventive grasses were removed from an area of short-tussock grassland near Cass, central South Island, and tussock survival, growth, and flowering monitored for 30 months. Tussocks increased in mean diameter in both weeded and control plots, however tussocks in weeded plots increased more in diameter. If the abundance of adventive species remains at present-day levels, or increases, as is more likely, they will probably have a long-term impact on the adult *F. novae-zelandiae* population.

Keywords: competition - invasion - removal - *Festuca novae-zelandiae* - *Agrostis capillaris* - *Anthoxanthum odoratum*

Introduction

In his book on the vegetation of New Zealand, Cockayne (1928) described two important grassland types in New Zealand: tall-tussock grassland dominated by *Chionochloa* species which are often 1m or more in height; and short-tussock grassland dominated by species such as *Festuca novae-zelandiae* and *Poa cita*, which are commonly around 60 cm in height. Since the colonisation of New Zealand by European pastoralists around 150 years ago, both grassland types have been used extensively for low productivity sheep farming. However, in the second half of this century, more attention has been paid to the conservation of tall-tussock grassland (Scott 1979, O'Connor 1982) whereas short-tussock grassland has been more degraded than the bulk of tall-tussock grassland (Scott 1979, Scott *et al.* 1988, Treskonova 1991, Rose *et al.* 1995).

Over the last century, short-tussock grassland has been undergoing a process of radical change from a community dominated by indigenous grasses, forbs and shrubs to one dominated by adventive species. Early accounts of short tussock grassland (e.g. Wall 1922, Cockayne 1928, Zotov 1938) list species that are now rare or absent in many areas and much of the present-day short tussock grassland has been fragmented into patches of indigenous species in an alien matrix (Lord & Norton 1990). Some of the common adventive species in short tussock grassland such as *Agrostis capillaris*, *Anthoxanthum odoratum* and *Festuca rubra,* were deliberately introduced in order to improve the value of the vegetation for grazing (O'Connor 1982). However many others such as *Hypochoeris radicata*, *Hieracium* species, *Linum catharticum* and *Rumex acetosella* have spread by incidental introductions (Dobson 1977).

It is difficult to determine empirically the impact of biological invasion on the resident community, as effects are often subtle and slow to be manifest. However, recent long-term studies have linked the decline in indigenous species diversity in New Zealand tussock grassland to the increasing dominance of adventive species (Scott *et al.* 1988, Lord 1990, White 1991, Treskonova 1991, Rose *et al.* 1995). Major changes in the composition of a community are frequently the direct result of competitive interactions among individuals. This study aimed to examine the effect of introduced pasture grasses on adult growth and survival of a widespread, and physiognomically dominant, short-tussock species, *Festuca novae-zelandiae*.

Methods

The study was conducted in an area of short-tussock grassland near the University of Canterbury Field Station at Cass, South Island, New Zealand (43°02'S, 171°45'E). This grassland is dominated by *Festuca novae-zelandiae* tussocks in a matrix of adventive grasses such as *Agrostis capillaris, Anthoxanthum odoratum* and *Festuca rubra* var. *commutata*. The site has been under grassland for approximately five hundred years; the *Nothofagus* forest that covered the site prior to this was removed by fire (Molloy 1977). The main influx of adventive species presumably occurred with the advent of pastoral farming in the early 1860's (Dobson 1977). In 1915 a number of species including *Anthoxanthum odoratum, Holcus lanatus, Rumex acetosella* and *Trifolium repens*, which are common in the area today, were already present (Cockayne & Foweraker 1916). *Agrostis capillaris*, which is one of the most dominant inter-tussock species in the area, was not recorded as present even as late as the 1920's (Malcolm 1925). However by 1944 it was common on the valley flats (Cumberland 1944) and was possibly deliberately sown (Dobson 1977).

The simplest way to test for competition is, as Tansley (1914) stated "by clearing a patch of ground of some or all of the species present and seeing what happens". A 20 m transect was randomly located in the study area, and 7 points randomly located along the transect. At each point a pair of 1 m x 1 m plots were established, either side of the centre line and all adventive species were removed by hand from one randomly selected plot in each pair in January 1990. Rhizomes of *Agrostis capillaris* and *Hieracium* species were carefully dug out with a knife. All tussocks in the control plots were tagged and all plants in the weeded plots were mapped.

Every tussock was measured for maximum extended leaf length and mean basal diameter (using a diameter tape). In addition the percentage of tussock basal area occupied by dead material was estimated and the number of culms counted for each plant. The plots were weeded again in May and November 1990 and finally in February 1991. In January 1992 the same tussocks were reassessed for maximum extended leaf length, mean basal diameter, % dead material and number of culms.

As the data consisted of measurements on individuals in paired plots, a Paired T-test was used to analyse the effect of weeding on the amount of change in each factor measured. The amount of change in each factor was taken as the 1992 value less the 1990 value. All Paired T-tests were constructed as (change in control plot) minus (change in weeded plot). The change in relative reproductive effort, calculated as the number of culms m^{-2} of live basal area, was also tested for a significant treatment effect in this manner.

Results

The most common adventive species removed from the weeded plots were *Agrostis capillaris* and *Anthoxanthum odoratum*. A total of 255 tussocks were measured in January 1990 and 246 of these

Table 1 Mean values (Std. dev.) for 1990 and 1992 measurements of *Festuca novae-zelandiae* tussocks in weeded and control plots at Cass. Height and Diameter are in centimetres. 'Rel. eff.' is relative reproductive effort calculated as culms m^{-2} of live basal area. Results from Paired T-tests are also given. NS = not significant. Dead plants were excluded from the analysis.

		Height	Diameter	% Dead material	No. culms	Rel. eff.
1990	Control	39.44 (10.11)	4.639 (4.523)	29.60 (17.32)	1.542 (4.153)	765.6 (2474)
	Weeded	42.42 (9.508)	6.040 (4.864)	31.93 (14.03)	2.857 (5.813)	740.4 (1236)
1992	Control	38.18 (10.67)	5.444 (4.977)	16.58 (12.80)	4.135 (9.264)	1314 (2609)
	Weeded	36.05 (10.38)	8.086 (5.350)	15.55 (11.49)	7.055 (11.40)	989.5 (1310)
Paired T-tests: ('92-'90 control plot value) - ('92-90 weeded plot value). DF=13						
Mean difference		5.040	-1.078	3.348	-0.888	-88.04
T		4.74	-4.01	1.23	-0.61	-0.31
P<		0.001	0.01	NS	NS	NS

were still alive in January 1992. All nine deaths involved small plants in weeded plots, and death was possibly due to the increased exposure of plants with associated wind damage and desiccation. Also unavoidable disturbance of the soil and root zone of tussocks during weeding may have increased the likelihood of mortality.

In both control and weeded treatments, plants decreased in height on average through time, but increased in diameter and contained less dead material by the end of the study (Table 1). The decrease in height was significantly greater in weeded plants than in control plots, and the increase in diameter was significantly greater in weeded plots. There was no significant difference between control and weeded plots in the percent of basal area occupied by dead material, the average number of culms produced per plants, or in relative reproductive effort (Table 1).

Discussion

The increased growth of *F. novae-zelandiae* tussocks in weeded plots indicates that other species in the grassland have a detrimental effect on this species, and the lack of difference between weeded and control groups in the amount of dead material in tussocks indicates that the greater increase in the size of plants in weeded plots was a result of an increase in tiller production rather than a decrease in the death and decay of tillers. The tillering response shown by plants in the weeded plots could have been due to higher light levels or temperatures at the tussock base. Kays & Harper (1974) found that mutual shading among populations of *Lolium perenne* affected tillering rates. Gold & Caldwell (1989) found that removing dead foliage from the base of *Agropyron desertorum* tussocks stimulated greater regrowth than removing upper portions. The effect of adventive grasses on adult *F. novae-zelandiae* tussocks may be to depress tillering rates, and also culm production by association, due to competing for light. Interestingly, plants in both treatments on average increased in diameter and contained less dead material by the end of the study. This could possibly reflect a regeneration response following a year of low preciptation in 1989 (Lord 1992).

My data do not prove that any of the effects described above were specifically due to competition with adventive grasses as opposed to indigenous species, as it was very difficult to avoid removing smaller indigenous grasses during the weeding process. In a species removal experiment in a mown field in North Carolina, Fowler (1981) found that species generally increased in abundance on the removal of other species but that competitive interactions were diffuse rather than specific. It is possible that the findings of my study relate to competition generally rather than the specific effect of adventive species. *F. novae-zelandiae* might have shown a similarly positive response had I removed all other species instead of just targetting the adventives. However no other indigenous species was as abundant in the grassland I studied as the most abundant adventive species. The adventive species therefore represent the primary source of competition with *F. novae-zelandiae* tussocks at the study site.

In conclusion, this study indicates that the sward of adventive grasses at Cass may not be dense enough to have the strongly negative impact on tussock growth and survival observed in more fertile grassland (Lord 1990). However, adventive grasses such as *Agrostis capillaris* are still increasing around Cass (White 1991) and have formed a dense sward on some parts of the study area. Even if the abundance of adventive species remained at present-day levels, they would probably have a mild ongoing impact on the adult *F. novae-zelandiae* population; any further increase in abundance is likely to have long-term effects on the vigour and ultimate survival of adult *F. novae-zelandiae*. Furthermore, observations during the course of this study indicate that the spread of adventive grasses may be negatively affecting some indigenous species such as *Coprosma petriei,* that are important substrates for the regeneration of *F. novae-zelandiae* by seed (Lord 1992). Even in the absence of a strong negative effect on adult plants this would ultimately reduce the abundance of *F. novae-zelandiae* at the site.

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